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PATENT AND TECHNICAL TRANSLATION

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DECLARATION

The undersigned, Olaf Bexhoeft, hereby states that he is well acquainted with both the English and German languages and that the attached is a true translation to the best of his knowledge and ability of the German text of PCT/DE03/00163, filed 01/22/2003 and published 08/14/2003 under No. WO 03/066492 A1, and of twenty-nine (29) amended claims.

The undersigned further declares that the above statement is true; and further, that this statement was made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or document or any patent resulting therefrom.

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Specification

Method and Device for Controlling the Tension of a Web

The invention relates to a method and a device for regulating a web tension in accordance with the preamble of claims 1, 2 or 24.

A method for regulating the web tension is disclosed in EP 0 837 825 B1 wherein, besides the measured actual values of the web tension, further values defining the machine status and method-related properties are employed for the regulation. Besides the actually measured tension values, predeterminable web-specific parameters are also included in the regulating algorithm.

DE 198 34 725 A1 shows, inter alia, a method for regulating a web tension, wherein actual web tension values upstream and/or downstream of the printing unit are entered into a regulating device, which regulates the web tension at the draw-in device in such a way that, in spite of interference values such as, for example, a varying module of elasticity of the web, the web tension is maintained within a range which is optimal for the inking and cutting registrations.

The object of DE 197 54 878 A1 is to provide a winding tightness on a roll as constant, or pre-definable, as possible.

For obtaining a uniform wind-up roll curve, values measured by means of the unwinding roll curve are used for affecting the forces in accordance with the desired paper winding characteristic reference variable (winding tightness). Then the measured values are used together with the empirical values.

The object of the invention is based on creating a method and a device for regulating a web tension.

In accordance with the invention, this object is attained by means of the characteristics of claims 1, 2 or 24.

The advantages which can be attained with the invention consist in particular in that by means of a pre-control or pre-regulation it is possible to reduce effects on the printing process to be expected in the course of a foreseeable interference, in particular a roll change, and therefore to minimize the amount of occurring waste. The regulation takes place chronologically shortly prior to or at the start of the interference with an affected unit and not after a negative effect. By means of this method it is possible to reduce a long settling time, as well as the danger of a web tear. The reduction, or removal of the effect of a foreseeable interference therefore anticipates the interference itself, or takes place simultaneously with the buildup of the interference without having to rely on retroactively determined measured values. In a further development it is possible to additionally refer to measured values of the web tension. This can be advantageous for optimization and/or for a self-optimizing or learning system.

In connection with interferences in the course of changing webs of material to be imprinted, or their rolls, in particular, it is possible to counteract them with the aid of the regulation,

and the occurring waste can be minimized. This is achieved in an advantageous embodiment in that a pre-regulation or pre-control of drive mechanisms or adjusting elements in view of the expected changes in the web tension takes place during the gluing, the cut-off of the "old" web, or the entry into the printing press of the start of a fresh web to be imprinted.

By means of the pre-regulation or pre-control, the response times of regulating device which is operated "retrospectively" during the production (cause - effect - countermeasures), and/or the response time or the asymptotic approach to the reference variable, are clearly reduced. An elaborate color registration for compensating a negative result of the roll change can be omitted. In connection with one exemplary embodiment, the tension at the draw-in unit is preferably reduced by a predeterminable value, and in another exemplary embodiment to a predeterminable value.

If a web tension regulating device for the running operation of the printing press already exists, it is advantageous to add an offset to the reference variable of the web tension regulation at the draw-in unit. This offset can be overlaid on the reference variable at the draw-in unit as a one-time value, in the form of discrete steps, or as a continuous function within a time interval. In a further development, the time interval can be preset, for example, as a function of the running time of the glue spot from the roll changer to the hopper inlet, i.e. as a function of the production speed (number of revolutions), and possibly the path. In another exemplary embodiment, the offset, or the reduction is entered without a ramp in the form of a stepped function at the relevant time.

If there is no regulating device operating automatically during production, the actuator drives or the individual drive mechanisms can undergo a correction, for example by means of an appropriate actuating command, already at the occurrence, or in the run-up stage of the occurrence of the interference, for example the entry of the fresh web start into the printing press, in order to minimize or compensate the expected error.

Exemplary embodiments of the invention are represented in the drawings and will be described in greater detail in what follows.

Shown are in:

Fig. 1, a schematic representation of a rotary printing press with web tension regulation,

Fig. 2, a schematic representation of the chronological progression of a tension without applying the method,

Fig. 3, a schematic representation of a first exemplary embodiment of the chronological progression of the change of a reference variable for the regulation of the tension,

Fig. 4, a schematic representation of a second exemplary embodiment of the chronological progression of the change of a reference variable for the regulation of the tension,

Fig. 5, a schematic representation of a third exemplary embodiment of the chronological progression of the change of a reference variable for the regulation of the tension.

A processing machine, for example a web-fed rotary printing press, has several processing steps, or units, along the path of a web 01, for example a web 01 to be imprinted, in particular a paper web 01, in the transport direction T.

For a web-fed rotary printing press as schematically represented in Fig. 1, these can be, for example, a roll changer

02, a draw-in unit 03, one or several printing units 04, 06, a traction roller 07, if desired a longitudinal cutting device 08, turning devices 09 and registration devices 11 such as, for example, a linear registration roller 11, a further traction roller 12, for example in the form of a so-called hopper inlet roller 12, as well as formers 13 and a folding unit 14 with transverse cutting devices, not represented. In addition to this, further, non-represented processing steps can be arranged, such as a varnishing unit, dryer, etc.

Each printing unit 04, 06 has one or more printing groups 16, 17, 18, 19, for example double printing groups 16, 17, 18, 19 for imprinting on both sides, wherein the printing groups 16, 17, 18, 19 can be arranged side by side or also on top of each other. If several printing units 04, 06 are provided, these can also be next to or on top of each other with a horizontal or vertical path of the web 01.

The web 01 is unwound from the roll changer 02 and passes through the printing groups 16, 17, 18, 19, which print the web 01 sequentially, for example four times on the same side.

In order to maintain the congruence of the pages during multiple printing, or of the registration during printing on both sides, and of the cutting registration when combining several webs 01, 01', or partial webs 01, 01', and during transverse cutting, the maintenance of the congruence or the registration can be checked at one or several locations along the path of the web 01. For fully automatic printing presses this takes place, for example, by means of measuring the position of marks applied by the printing groups 16, 17, 18, 19, or of print images, by means of a sensor, not represented. In this case the signals from the sensor are supplied to a control unit, not represented, for

correcting the registered deviations in congruence or registration, whereupon actuating means, for example linear registration rollers, angle of rotation positions, etc., are actuated.

As a rule, changes in web tension are detected at one or several locations along the path of the web 01 by measuring rollers, such as the measuring roller 21 shown by way of example downstream of the last printing group 19, or in any other suitable way, are processed in a regulating unit 22 and are, in case of a deviation from a reference variable or a permissible range, returned to these. For example, the tension S1 downstream of the last printing group 19 is detected at the measuring roller 21, is processed in the regulating unit 22, and a signal for maintaining the desired tension S1 is sent to the drive mechanism of the traction roller 07 and/or the draw-in unit 03. A tension S0 upstream of the first printing group 16 in particular determines the level of all tensions along the path of the web 01 up to the entry into the hopper, and is regulated via the draw-in unit 03, for example.

In case of a measured, already occurring deviation of an actual value from the reference variable, a regulation principle operating "retrospectively" in this way returns the former to the desired reference variable by triggering drive mechanisms or actuating mechanisms. Such a regulating principle is employed, for example, during "normal" continued printing without large fluctuations in the conditions; it therefore reacts to already occurred and registered changes.

The causes of interferences, and changes resulting therefrom, can be many: for example changes in the printing press state, such as accelerations, changes of values in the printing

process, such as dampening agent and ink supply, changes in contact pressures, changes in the properties of the web 01, such as the tension-stretching behavior, of the thickness, the moisture absorption, etc.

A roll change, and the course of a connection 26 between an old and a fresh web 01, in particular a glue spot 26, through the printing press, represent a substantial, but also foreseeable interference. In comparison with the thickness of the single web 01, the glue spot 26 has a greater thickness, possibly also with the addition of an adhesive tape or an adhesive, and has elastic properties which are different from the web 01. In addition, the old and the fresh web 01 can also have different properties (moisture, winding tightness and/or tension-stretching characteristics).

In the course of their entry into the printing press, these interferences, in particular the last mentioned, cause a large change in the tension of the web 01 and registration errors connected therewith. Registration errors caused by a roll change between the printing groups 16, 17, 18, 19 cannot be compensated at all, or only by means of elaborate techniques, by means of the above mentioned registration regulation.

The instant method for regulation now provides a counteraction to the imminent changes in the tension SO, S1 in a way wherein a preset reference variable S0-soll, S1-soll is changed, in particular reduced. In a first example, the reference variable S0-soll, S1-soll is reduced by a definite amount Delta S-soll, and in a second example is reduced, at least temporarily, to a predeterminable reference variable S0-fix, S1-fix. In a preferred embodiment, both are performed by the reduction of the

reference variable S0-soll of the tension S0 upstream of the first printing group 16 by means of the draw-in unit 03.

Fig. 2 schematically shows a chronological progression of, for example, the tension S1 without the described method being applied. As soon as the glue spot 26 passes through the draw-in unit 03, a steep rise of the tension S1 starts and progresses as far as the entry of the glue spot 26 into the hopper inlet. The same applies for the course of the tension S0, but is chronologically offset slightly toward the "front", i.e. to the left in Fig. 2. Thereafter, the tension S1 is on a level increased by an amount DeltaS1 and decreases only slowly. The increased level of the tensions S0, S1, etc., deviating in particular with a large amplitude from the reference variable S0-soll, S1-soll, causes registration errors between the printing groups 16 to 19 because of the change in the stretching.

Now, in a first exemplary embodiment (Fig. 3), these registration errors are avoided, or reduced, in that the reference variable S0-soll of the tension S0 is reduced by the amount Delta S-soll. This predetermined amount Delta S-soll can advantageously be changed and corresponds, for example, to a mean empirical value of the expected increase, without an appropriate reduction, of the tension S0 by the amount Delta S0. In particular, the amount Delta S0 can be selected in such a way that after the reduction of the tension S0 resulting from the change of the reference variable S0-soll, the tension S0 initially swings below the original reference variable S0-soll, S1-soll and, following a pass through the reference variable S0-soll, S1-soll, swings above the reference variable S0-soll, S1-soll, wherein the respective absolute deviation at the minimum or maximum from the original reference variable S0-soll, S1-soll is considerable in contrast to

the resulting deviation without the reduction. The tension S0, S1 fluctuates with a clearly reduced amplitude around the original reference variable S0-soll, S1-soll. This amount Delta S-soll can be stored, for example, in a memory unit 23 or determined in a computing unit 23 (Fig. 1).. In the case where the changes in the tensions S0 and S1 are of the same size, it can correspond to the amount Delta S1, represented only as an example of the tension S1 in Fig. 2 or, as described above, to a portion of this amount Delta S1. However, it can also be determined by means of a chronological progression of the tension S0 corresponding to Fig. 2, or in other ways, for example by tests.

The chronological progression of the reference variable S0-soll is schematically applied in Fig. 3, parallel with the tension S0 or S1 in Fig. 2. In the course of the passage of the glue spot 26 through the draw-in unit 03, or slightly prior to that (in particular shortly before the actuation of a severing blade, or at that time at the latest), the reference variable S0-soll is reduced. This can take place in a single step, or continuously (for example in the form of a ramp), or in several stages, as represented in Fig. 3. In the present embodiment (Fig. 3), the reference variable S0-soll is not reduced in one step, but during a time interval Delta t, which for one can be determined from empirical values, but in particular from the running time of the web 01 from the draw-in unit 03 to the hopper inlet roller 12. In one embodiment, the reference variable S0-soll, reduced in the end by the amount Delta S-soll, can be maintained over a time interval Delta t' (Fig. 3) past the time of the maximum of the tension S1 (Fig. 2) which would be expected without the reduction, before the reference variable S0-soll is returned, either in one step, or continuously, or in steps, back to the reference variable S0-soll

desired for the printing press status. The "normal" tension regulation, if provided, then alone again takes over the regulation of the tensions S0, S1.

In a second exemplary embodiment (Fig. 4), the reference variable S0-soll is not reduced by a fixed amount Delta S-soll, but temporarily to a fixed new value S0-fix, which can be predetermined and/or changed. For example, by means of this it can be assured that the tension S0 upstream of the printing unit does not drop so far that the tension S1 downstream of the printing unit 04 falls into a range which is critical for the web run, for example below 8 daN/m.

The chronological progression of the reference variable S0-soll is represented in Fig. 4, which initially remains at a constant level. Now, in the course of a foreseeable interference, in particular a roll change, this reference variable S0-soll is purposely reduced to a fixed value S0-fix. As already mentioned, the reduction can in principle take place at any arbitrary, but fixed, time in relation to the time of the roll change and is triggered by various signals provided to the control/regulation of the printing press, or also by measured signals.

However, it is advantageous if the reduction takes place no later than the occurrence of the interference, but better yet shortly prior to the interference. In the case of the flying roll change considered, the interference occurs with the gluing of the fresh web 01 to the old web 01 and the almost simultaneous cutoff of the old web 01. In an advantageous embodiment, this time t_K (gluing and/or cutting) constitutes the reference point for reducing the reference variable S0-soll of the tension S0 upstream of the printing unit 04 by means of the draw-in unit 03.

Although the reduction in accordance with the example in Fig. 4 is tied to the gluing process (activation of the gluing roller and/or of the severing blade), it does not have to take place at the time t_K of the triggering of the gluing roller and/or the severing blade, but can take place earlier while expecting gluing/cutting. As represented in Fig. 4 by means of the time interval Delta t_K, reducing the reference variable SO-soll takes place at a fixed, but settable chronological distance prior to the time t_K of the gluing/cutting. For example, the time interval lies between 50 and 400 ms, in particular between 50 and 250 ms. Matching and optimizing of the above mentioned "back swing" to the printing press and the path of the paper can take place by means of the selection of the time interval Delta t_K.

Since the time for reducing the reference variable S0-soll lies prior to the actual time t_K for gluing/cutting, it is advantageous to tie the time for the reduction to information regarding the printing press state or measured values, by means of which the time t_K for gluing/cutting is also determined. For example, this can be a known diameter of the old roll to be changed. The time for the reduction can also be correlated in relation with a process which has a defined chronological connection with the gluing/cutting. Such a process is, for example, the bringing of a gluing frame into position, i.e. a time t_S of the signal for pivoting. Such a time lies, for example, between 100 to 500 ms prior to the time t_K for gluing/cutting, so that the reduction lies approximately 50 to 450 ms after the time t_S for pivoting. The reduction can be tied, for example, to a defined roll diameter, for example 130 mm, and gluing/cutting tied to 125 mm. The distance between the two values used can also be

correlated with the instantaneous production speed, or number of revolutions (for example linearly).

The predetermination of the reference variable, i.e. the reference variable S0-soll, is now reduced to S0-fix, for example without a chronological ramp in one step, and remains there for a constant, but predeterminable time interval Delta t1. Subsequently the reference variable S0-soll is raised along a ramp (possibly also along a step function) within a time interval Delta t2 back to the original reference variable S0-soll. The time intervals Delta t1 and Delta t2 have, for example, been selected to be on the same order of magnitude, for example 0.5*Delta t1 ≤ Delta t2 ≤ 2.0*Delta t1. However, in principle it is also possible to perform the reduction in steps or along a steep ramp, for example.

If a different basic level of the tensions S0, S1 of the web 01 is desired for a different production - for example a different web course, a different sequence of the web 01 at the hopper inlet -, the reference variable S0-soll' initially lies, as represented in the example of Fig. 4 by means of a lower reference variable S0-soll', at this reference variable S0-soll' before it is also reduced to the fixed value SO-fix in order to be returned afterwards after the time interval Delta t1 to its original reference variable S0-soll' within the time Delta t2.

An example of a possible control circuit for regulating the tension S0 is schematically integrated in Fig. 1. In a conventional control circuit, the regulating unit 22 makes sure that the tensions S0, S1 are each maintained on the desired reference variable S0-soll, S1-soll. For this purpose, actual values S0-ist, S1-ist are provided as input values, are compared with the reference variables S0-soll, S1-soll, and appropriate

drive mechanisms are set by means of appropriate output values. For example, the reference variables S0-soll, S1-soll can be provided by a printing press control device 24, or can be formed in the regulating unit 22 itself from values g, which define the printing press status, in the regulating unit 22.

During a roll change, for example at the time of connecting, of severing the "old" web 01, or during the passage of the glue spot 26 through the draw-in unit 03, or at a time interval Delta t_K relative to one of these times, an amount Delta S-soll made available by the memory or computing unit 23 in the first exemplary embodiment, is added as a negative "offset", for example as a step function, to the reference variable S0-soll and is maintained during the time interval Delta t', for example, after the end value has been reached. In the second exemplary embodiment the reference variable S0-soll is decreased to the value S0-fix in order to maintain it there over the time interval Delta t and subsequently to return it to its original value along a ramp. Once the interruption has ended, i.e. the glue spot 26 at the former 13, or the additional time interval Delta t' or the time interval Delta t2 has passed, regulation is again left to the "normal" tension control device with the predetermined reference variables S0-soll, S1-soll, etc.

In a further development of the invention, the memory or computing unit 23 is additionally provided with, besides the information regarding the material, for example the type of paper and, for example, the web width, with substantial values g, which affect the properties or the behavior of the web 01, from the printing process, the printing press status and/or the web conveyance, such as, for example, supply of dampening agent and/or ink, actual web tensions, contact pressures, speed, temperatures,

accelerations and/or the course of the web 01. In the first exemplary embodiment it is possible to select the suitable temporary correction of the reference variable S0-soll by the amount Delta S0 for the tension S0, or to calculate it, or to determine the optimized chronological progressions (times and time intervals Delta t, Delta T1, Delta t2, Delta t') for the appropriate production in the two exemplary embodiments.

It is also advantageous if data regarding the amounts Delta S0 and/or Delta S-soll determined in the past, as well as in the present circumstances, are stored in the memory or computing unit 23. Together with the regulating unit 22, in a further development such a memory or computing unit 23 can then be embodied as a self-learning system and can optimize the regulating process performed for the roll change ahead of time or simultaneously. In the ideal case, no correction of the tensions S0, S1 need to be performed after the amount Delta S-soll has been completely returned, so that it can be used as a measure for the quality achieved by means of the correction.

Any other suitable method can also be applied for triggering the reduction of the reference variable S0-soll. It is thus possible, for example, to determine the time by means of the detection of the steep flank of one of the tensions S0, S1, or a visually detected passage of the glue spot 26 at a defined location, or the definition of a time relative to the roll change within the scope of a program of the printing press regulation. However, it is important that, for counteracting the interference, the reference variable for the tension is definitely changed, at least temporarily, and not only after the extent of the negative interference has been determined.

In contrast to the second exemplary embodiment, in a third exemplary embodiment the reference variable S0-soll is returned to the original reference variable S0-soll (or a new fixed reference value S0-soll') from the fixed value S0-fix not along a predetermined ramp, but on the basis of a measurement of the tension S1, S0, in particular the tension S1 downstream of the last printing unit 19 measured, for example, by means of the measuring roller 21. A new fixed reference variable S0-soll' can be necessary, for example, if the paper type, i.e. the basic properties, is also to be changed during the roll change. This information can then be taken from the printing press control, for example, and can be taken into consideration for the uninterrupted operation when forming the reference variable S0-soll, S1-soll, S0-soll'.

The return can be based for example on a continuous or discontinuous measured value pick-up wherein, however, a reference variable $S0\text{-soll}_m$, which is valid for the next time interval m, is determined in defined, possibly selectable, time intervals Delta t_m by means of the measured value and is supplied to the regulating device. A stepped return of the reference variable S0-soll resulting from this is represented by way of example in Fig. 5. However, the return to the original reference variable S0-soll (or a new fixed reference variable S0-soll') can also be determined in another way by means of the measured values S1-ist and preset. Thus it is possible, for example, to determine a slope of partial ramps in sections from two or several measured values, wherein then the ramp represented in Fig. 4 can have different slopes in sections as a function of the measured values.

The determination and regulation of the reference variables $S0\text{-soll}_m$, or of the sectionally determined slopes can be provided

from the measurements in an advantageous embodiment for example by means of a fuzzy regulation, in a simpler embodiment by means of a PID controller.

It is basically possible to combine the procedures of the three above mentioned examples. For example, a reduction in accordance with the example one and a return in accordance with the example three can take place. In all three examples it is also possible to provide predetermined ramps (possibly changeable ones) for the reduction. The return from the third example can be applied to the second example. In the same way the reduction by a defined amount Delta S-soll can also be transferred to the examples two and three, while the reduction to a defined fixed value S0-fix can be transferred to the example one.

List of Reference Symbols

01	Web, web to be imprinted, paper web, partial web
02	Roll changer
03	Draw-in unit
04	Printing unit
05	-
06	Printing units
07	Traction roller
08	Longitudinal cutting device
09	Turning device
10	-
11	Registration devices, longitudinal register roller
12	Traction roller, hopper inlet roller
13	Former
14	Folding unit
15	-
16	Printing group, double printing group
17	Printing group, double printing group
18	Printing group, double printing group
19	Printing group, double printing group
20	-
21	Measuring roller
22	Regulating unit, regulating unit
23	Memory unit, computing unit
24	Printing press control
25	-
26	Connection, glue spot

01'	Web, partial web
T	Transport direction
g	Value
S0	Tension
S1	Tension
S0-ist	Actual value of the tension
S1-ist	Actual value of the tension
S0-soll	Reference variable of the tension
$S0\text{-}soll_m$	Reference variable of the tension
S1-soll	Reference variable of the tension
S0-fix	Fixed reference variable
S1-fix	Fixed reference variable
S0-soll'	Reference variable of the tension
Delta S0	Amount, increase
Delta S1	Amount, increase
Delta S-soll	Amount, decrease
Delta t	Time interval
Delta t'	Time interval
Delta t1	Time interval
Delta t2	Time internal
Delta t_K	Time interval
Delta t_m	Time interval

t_K	Time, gluing/cutting
t_S	Time, pivoting